

Fermilab Booster Lattice Performance at Injection

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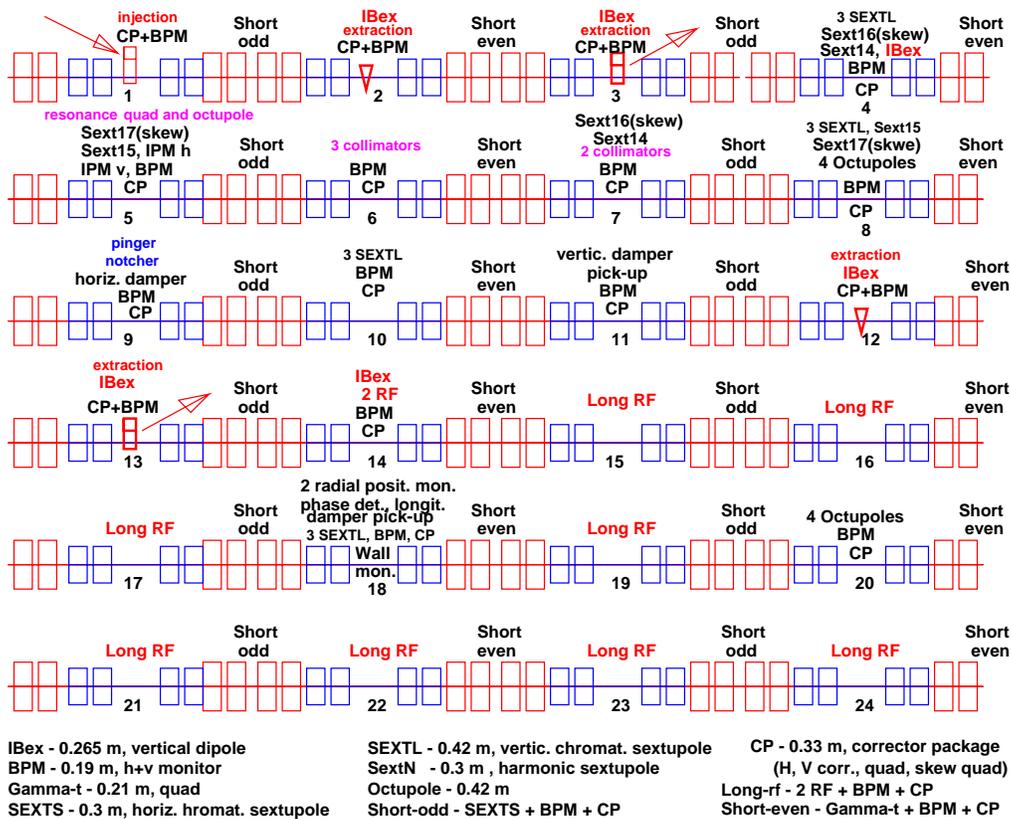


Figure 1: Booster lattice.

	α	γ_t	ν_x	ν_y	β_x (arc)	β_y (arc)	D	ξ_x	ξ_y
					m	m	m		
no injection and extraction bumps no magnets rotation	0.03371	5.4458	6.6997	6.8000	33.6730	20.4564	3.189	18.276	-0.024
no injection and extraction bumps with magnets rotation	0.03371	5.4458	6.6997	6.8000	33.6795	20.4604	3.190	18.276	-0.025
with injection bump, no extraction bumps, with magnets rotation, without multipole harmonics	0.03371	5.4463	6.6997	6.8256	33.6781	24.3444	3.190	18.275	0.569
no injection bump, with extraction bumps, with magnets rotation, without multipole harmonics	0.03235	5.5597	6.7670	6.8000	47.1687	20.4599	6.038	17.723	-3.749
with injection bump, with extraction bumps, with magnets rotation, without multipole harmonics	0.03234	5.5602	6.7670	6.8257	47.1695	24.3544	6.038	17.722	-3.628
with injection bump, with extraction bumps, with magnets rotation, without multipole harmonics in the extr.bump-magnets, with harmonics the injection bump-magnets	0.03236	5.5593	6.7621	6.8400	46.0823	26.9989	6.129	17.745	-3.884
with injection bump, with extraction bumps, with magnets rotation, with multipole harmonics in the extr. and injection bump-magnets	0.03236	5.5593	6.7621	6.8400	46.0914	26.9932	6.131	17.751	-3.905
with injection bump, with extraction bumps, without magnets rotation, with multipole harmonics in the extr. and injection bump-magnets	0.03236	5.5592	6.7621	6.8400	46.0911	26.9873	6.1287	17.752	-3.900

Table 1: Fermilab Booster lattice performance at injection.

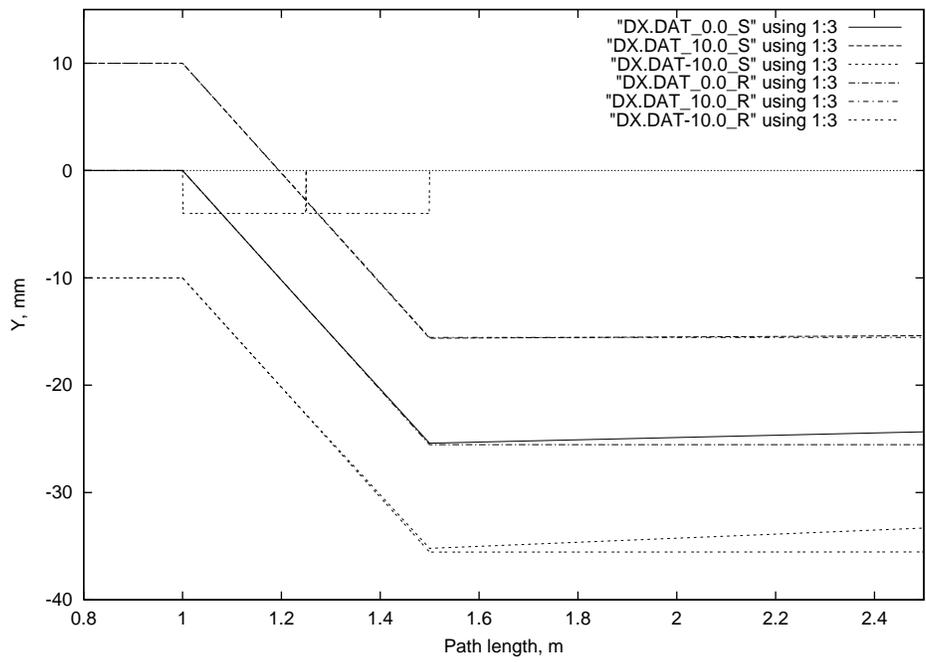


Figure 2: Proton trajectories in the “rectangular” and “sector” magnets with bending angle of 0.1 radian.

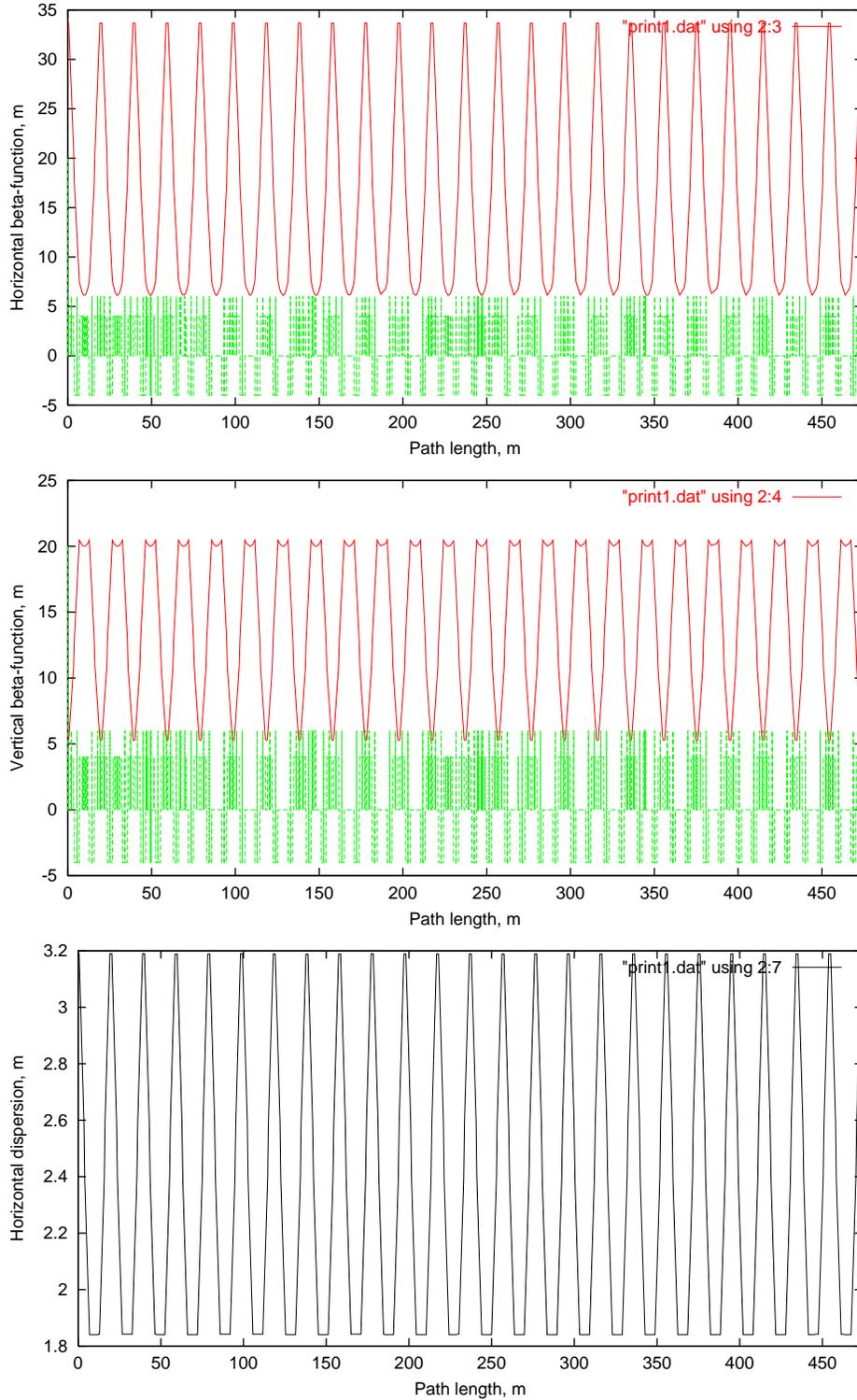


Figure 3: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection without injection bump at “long 01” straight section and without extraction bumps at “long 03” and “long 13” straight sections.

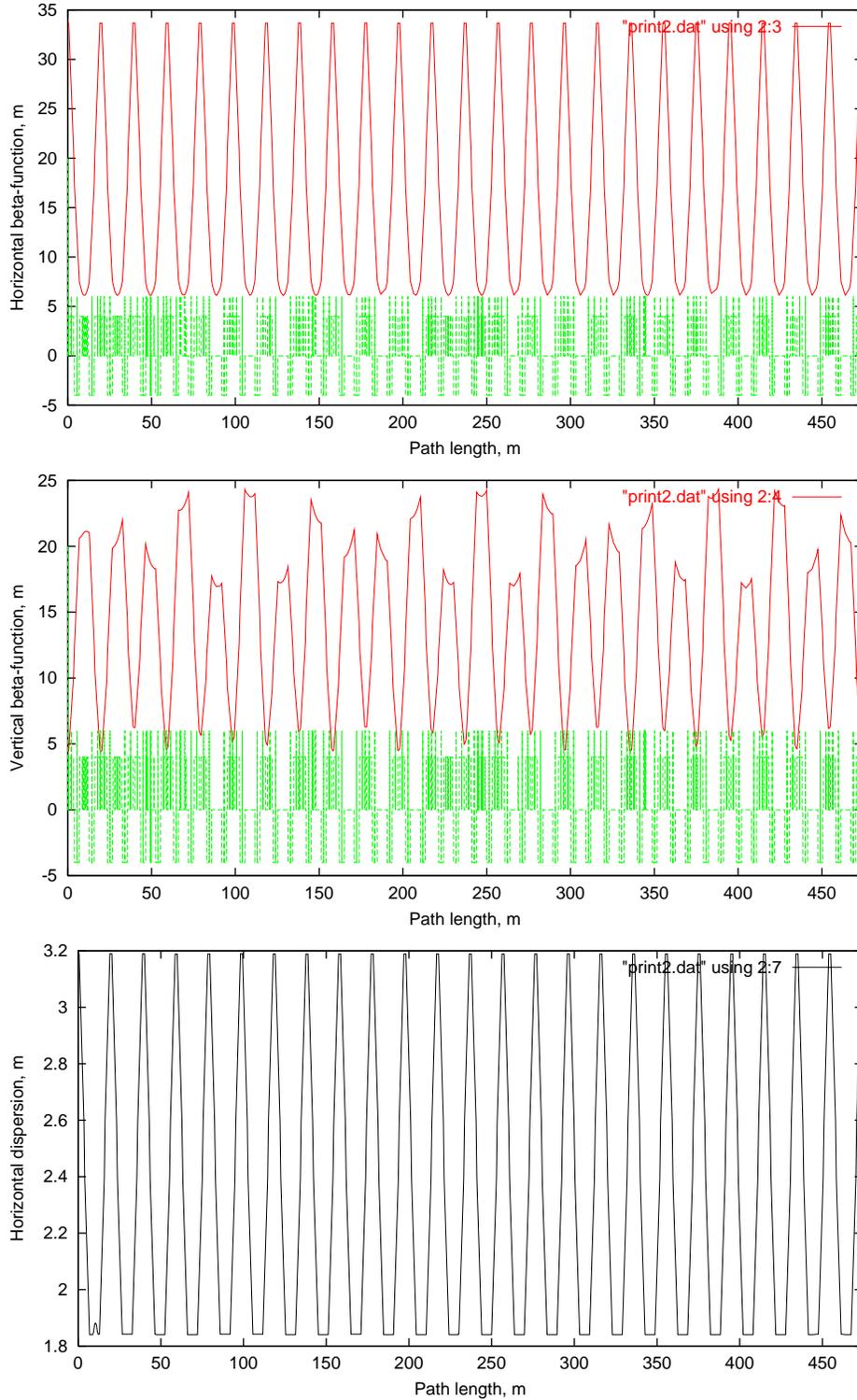


Figure 4: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and without extraction bumps at “long 03” and “long 13” straight sections. There are no multipole harmonics in the bump magnets.

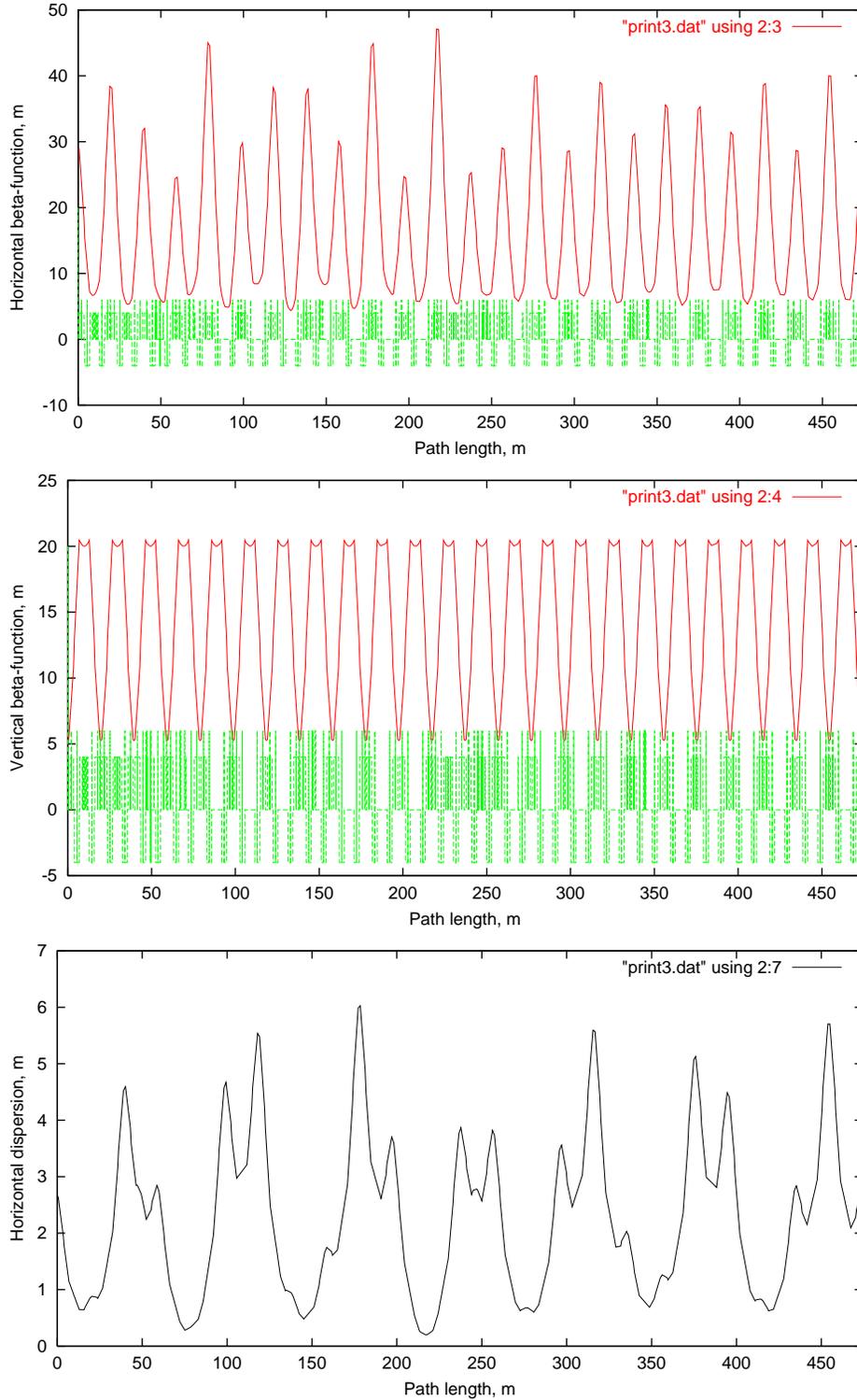


Figure 5: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection without injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. There are no multipole harmonics in the bump magnets.

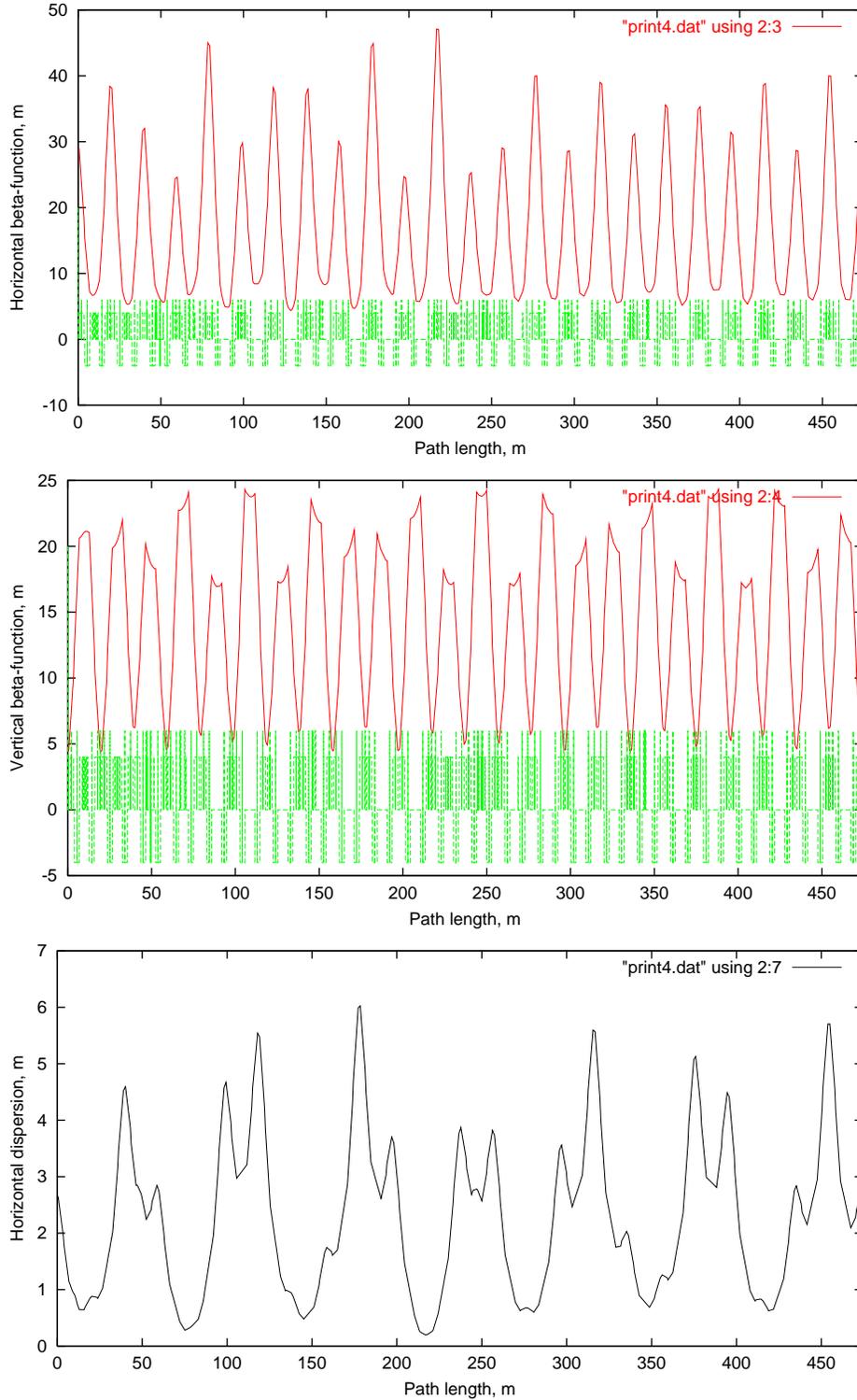


Figure 6: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. There are no multipole harmonics in the bump magnets.

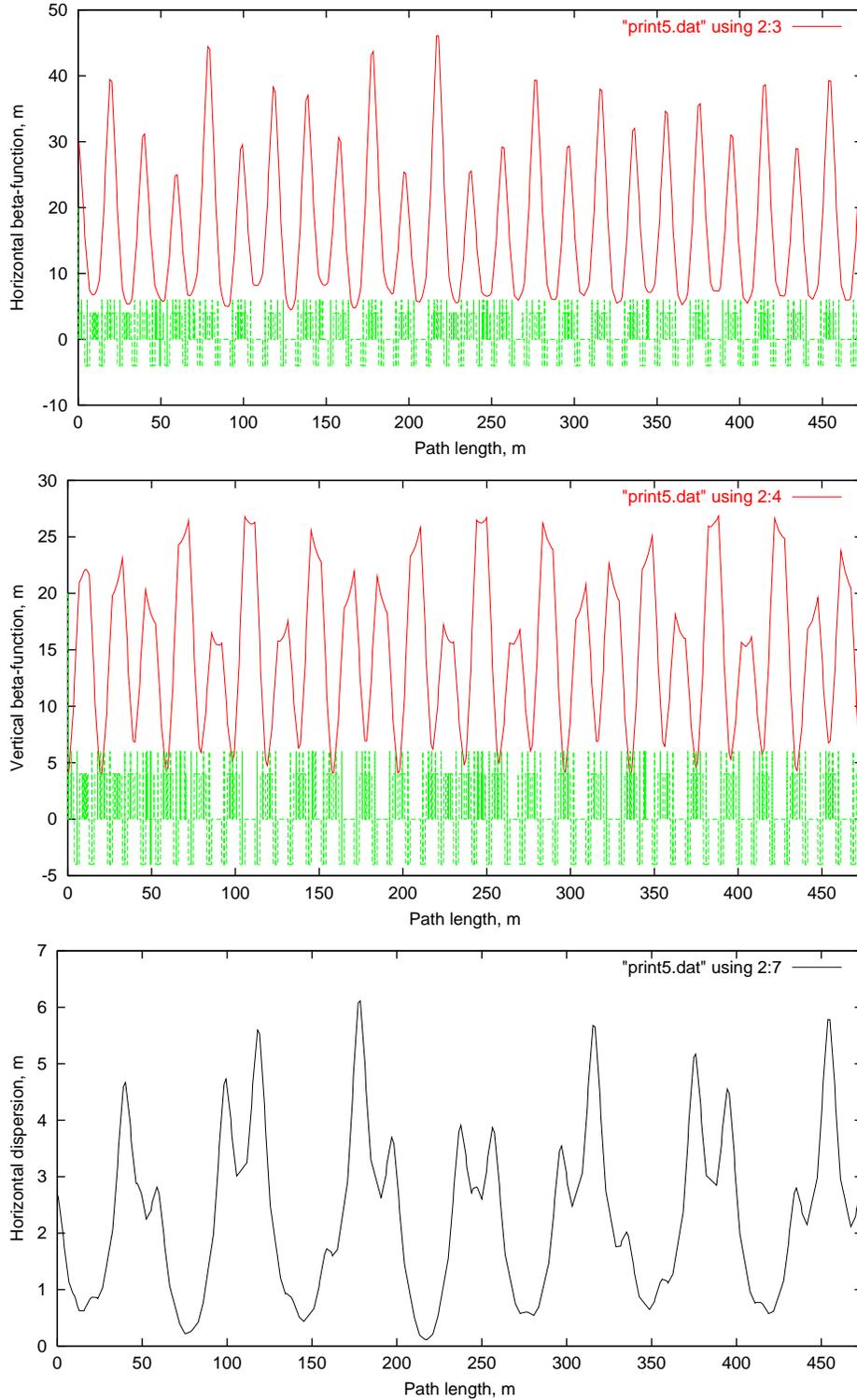


Figure 7: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the injection bump-magnets. There are no multipole harmonics in the extraction bump-magnets.

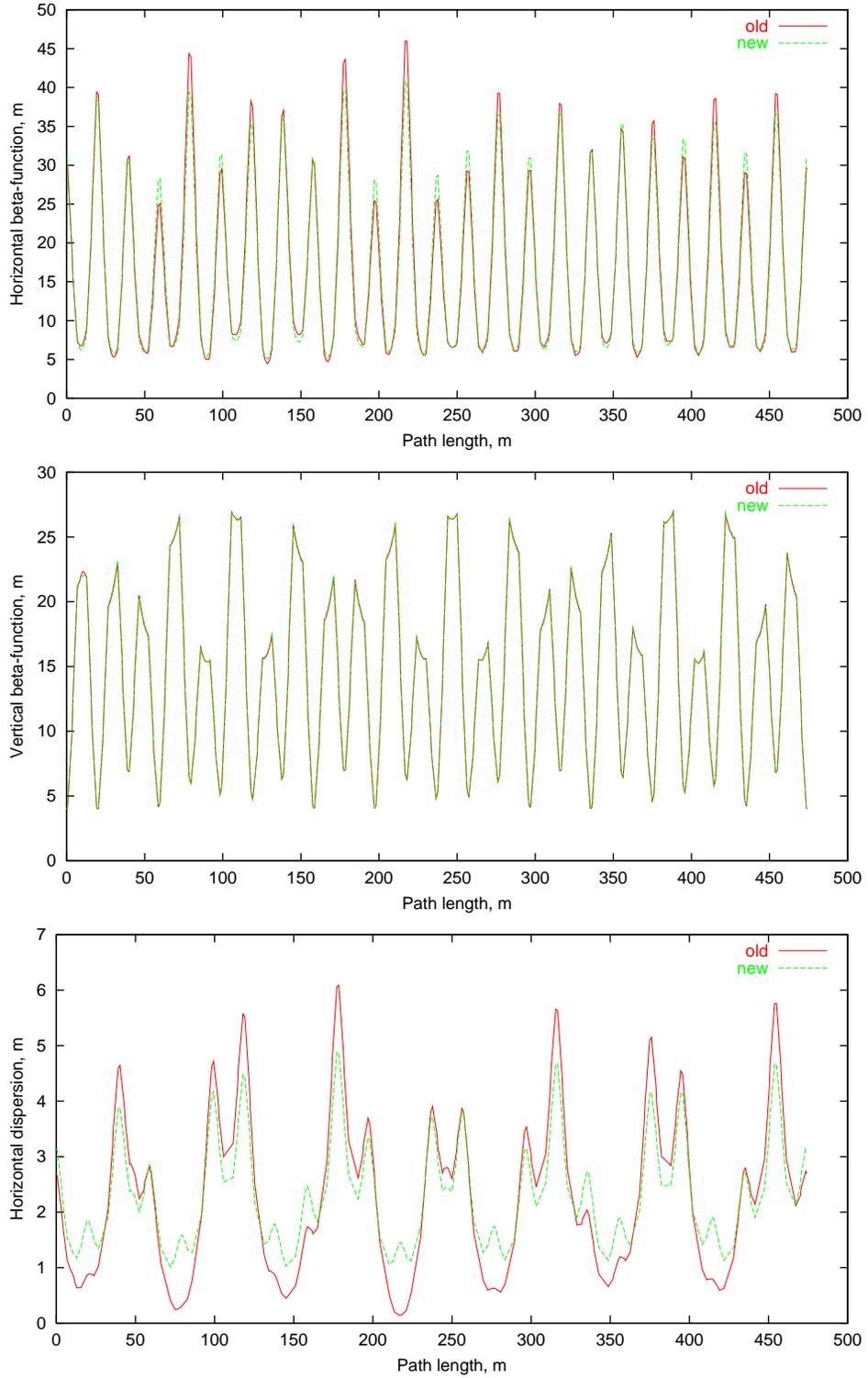


Figure 8: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the⁹ injection and extraction bump-magnets.

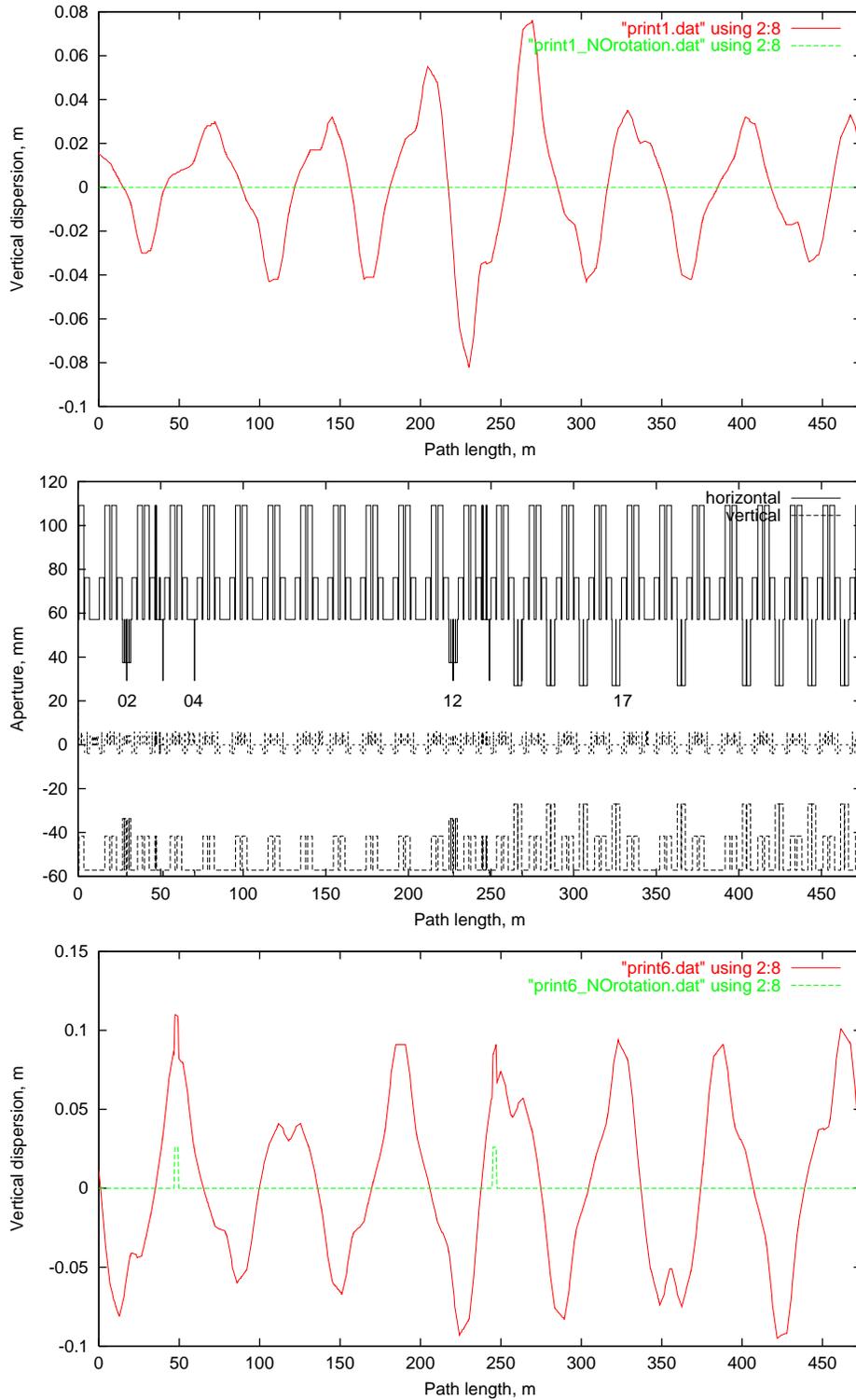


Figure 9: Fermilab Booster vertical dispersion with and without main magnets rotation at injection without injection bump at “long 01” straight section and without extraction bumps at “long 03” and “long 13” straight sections (top). Vertical dispersion with and without magnets rotation with multipole harmonics in the injection and extraction bump-magnets (bottom). Booster aperture is shown in the middle.

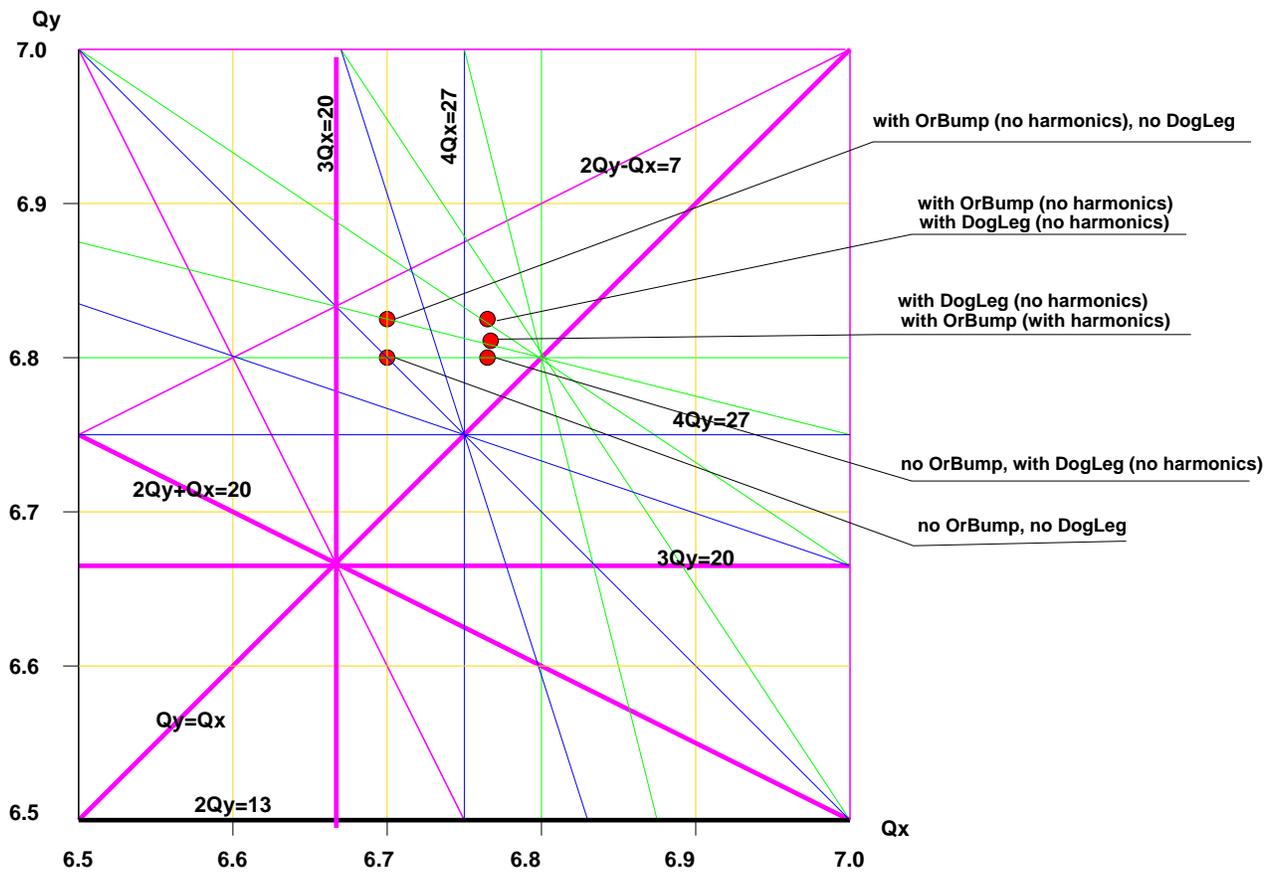


Figure 10: Fermilab Booster betatron oscillation tune at injection.

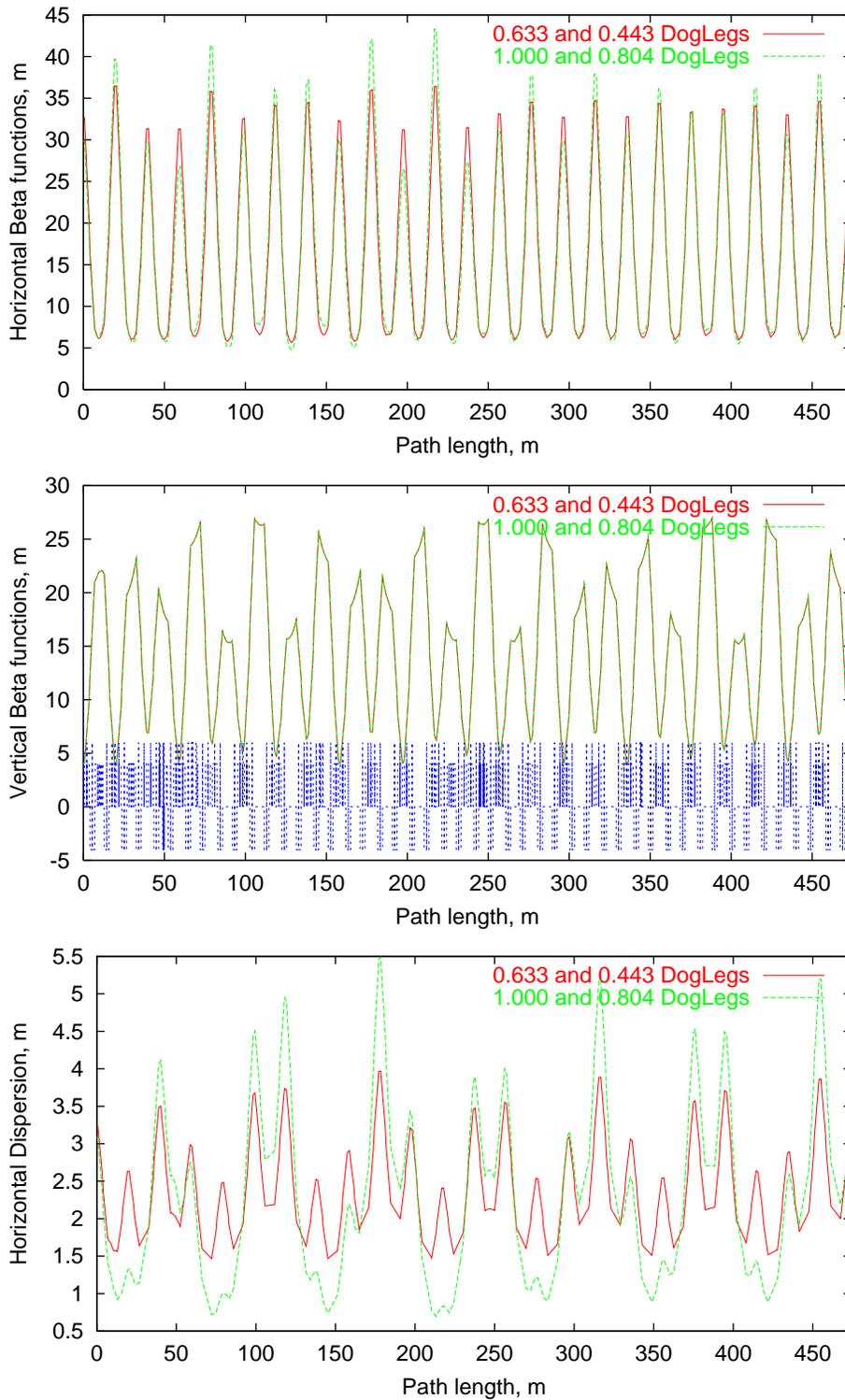


Figure 11: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the injection and extraction bump-magnets. Two cases are assumed: 1 - bump at “long 13” straight section is decreased with a coefficient of 0.804; 2 - bump² at “long 03” is decreased with coefficient of 0.633, and bump at “long 13” with coefficient of 0.443=0.804*0.551. Here 0.804=459.8A/572A, 0.633=362.4A/572A and 0.551=253.5A/459.8A are the ratio of actual currents in the magnets during the measurements.

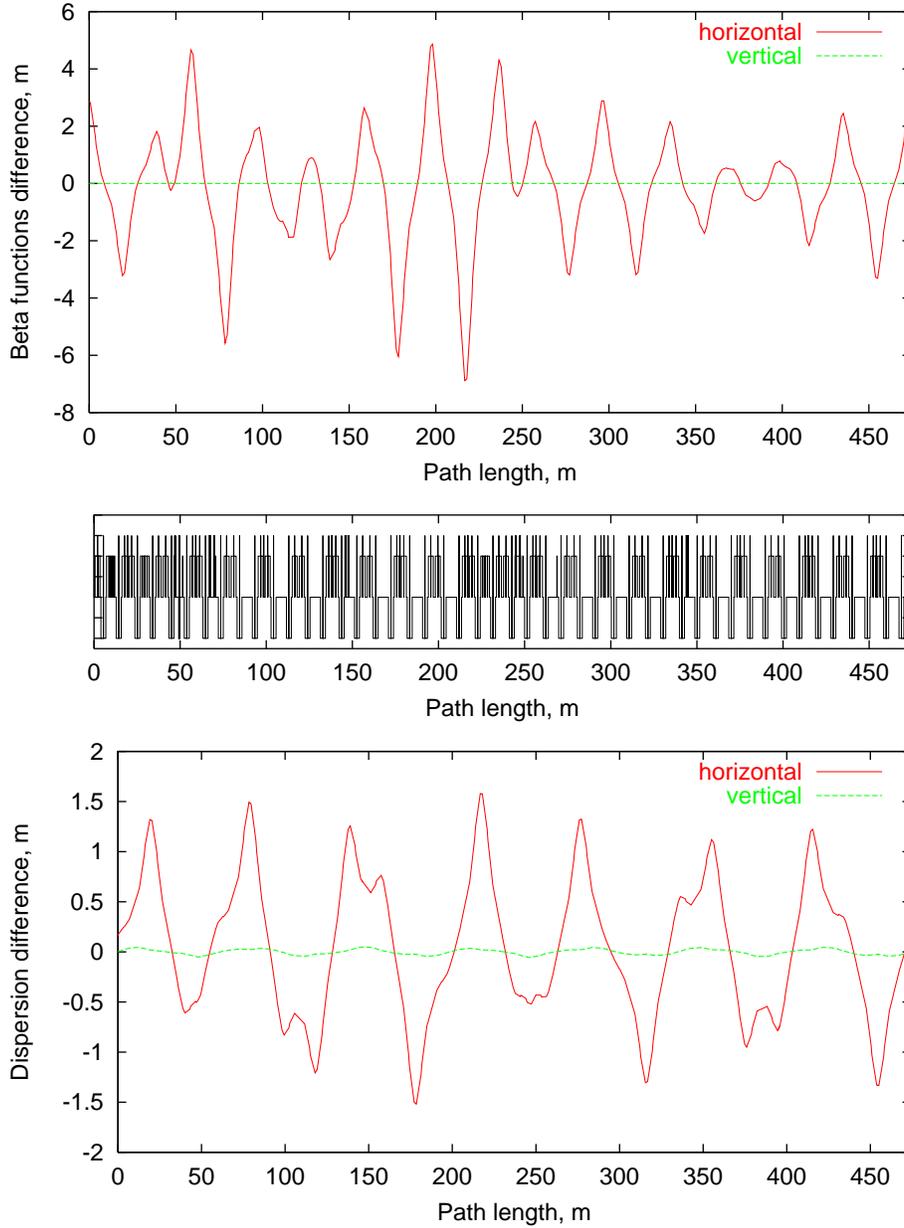


Figure 12: Difference in horizontal and vertical β functions (top) and horizontal and vertical dispersions (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the injection and extraction bump-magnets. Two cases are assumed: 1 - bump at “long 13” straight section is decreased with a coefficient of 0.804; 2 - bump at “long 03” is decreased with coefficient of 0.633, and bump at “long 13” with coefficient of $0.443=0.804*0.551$. Here $0.804=459.8A/572A$, $0.633=362.4A/572A$ and $0.551=253.5A/459.8A$ are the ratio of actual currents in the magnets during the measurements.

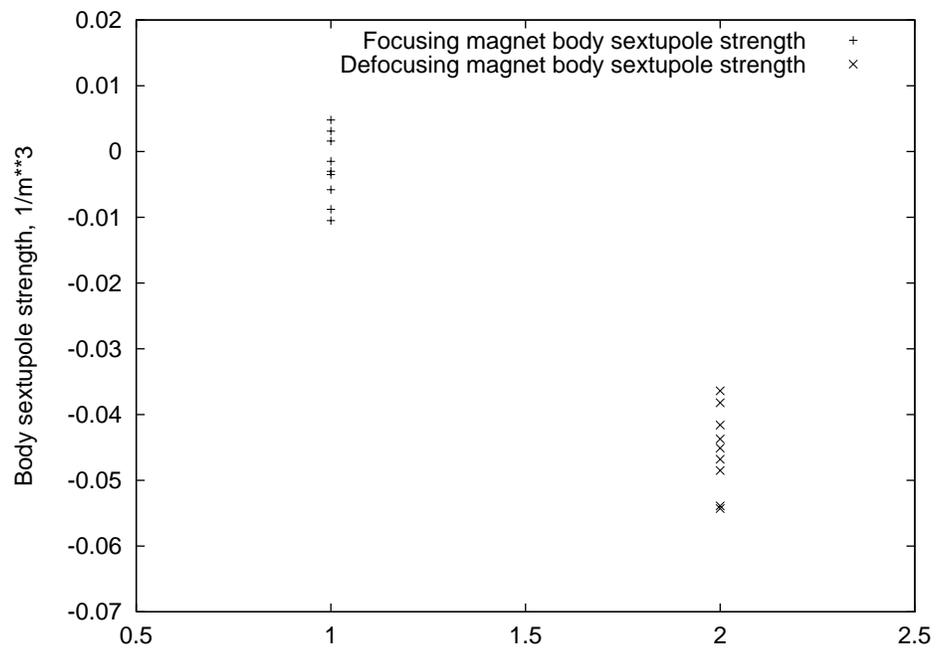


Figure 13: Calculated body sextupole harmonics in the Booster magnets.

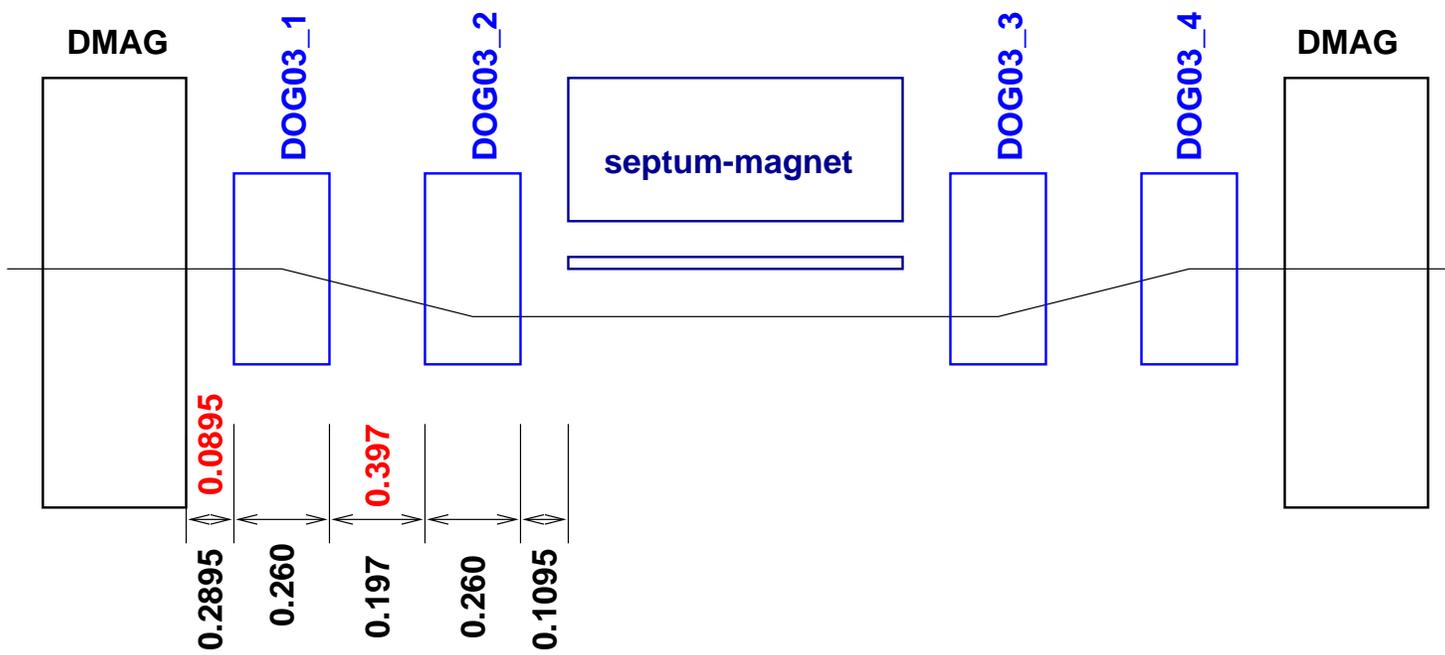


Figure 14: DogLeg bump magnets location in the Booster Long-03 straight section.

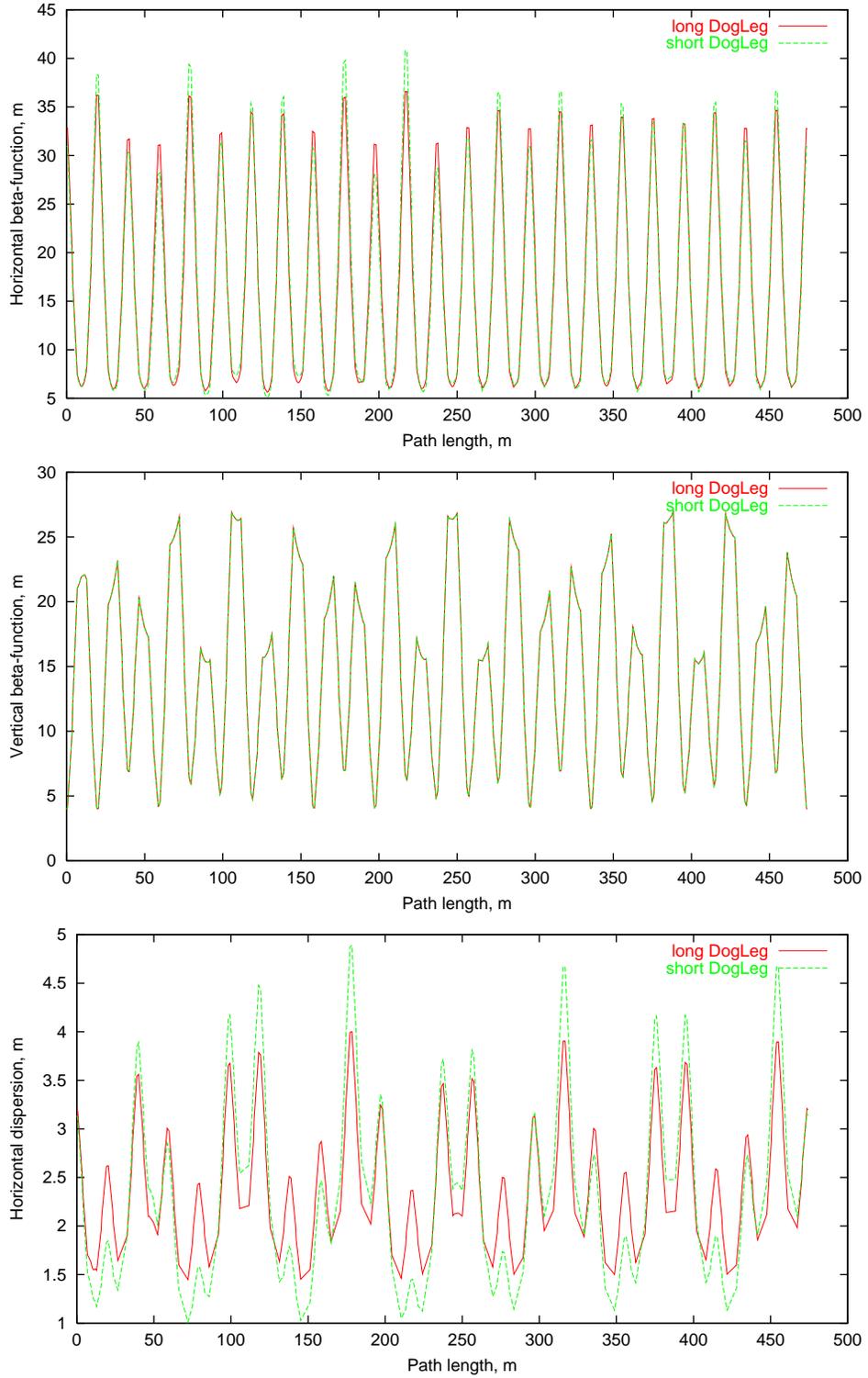


Figure 15: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the injection and extraction bump-magnets. With “short” distance between DogLeg magnets and with distance increased by 0.2 m.

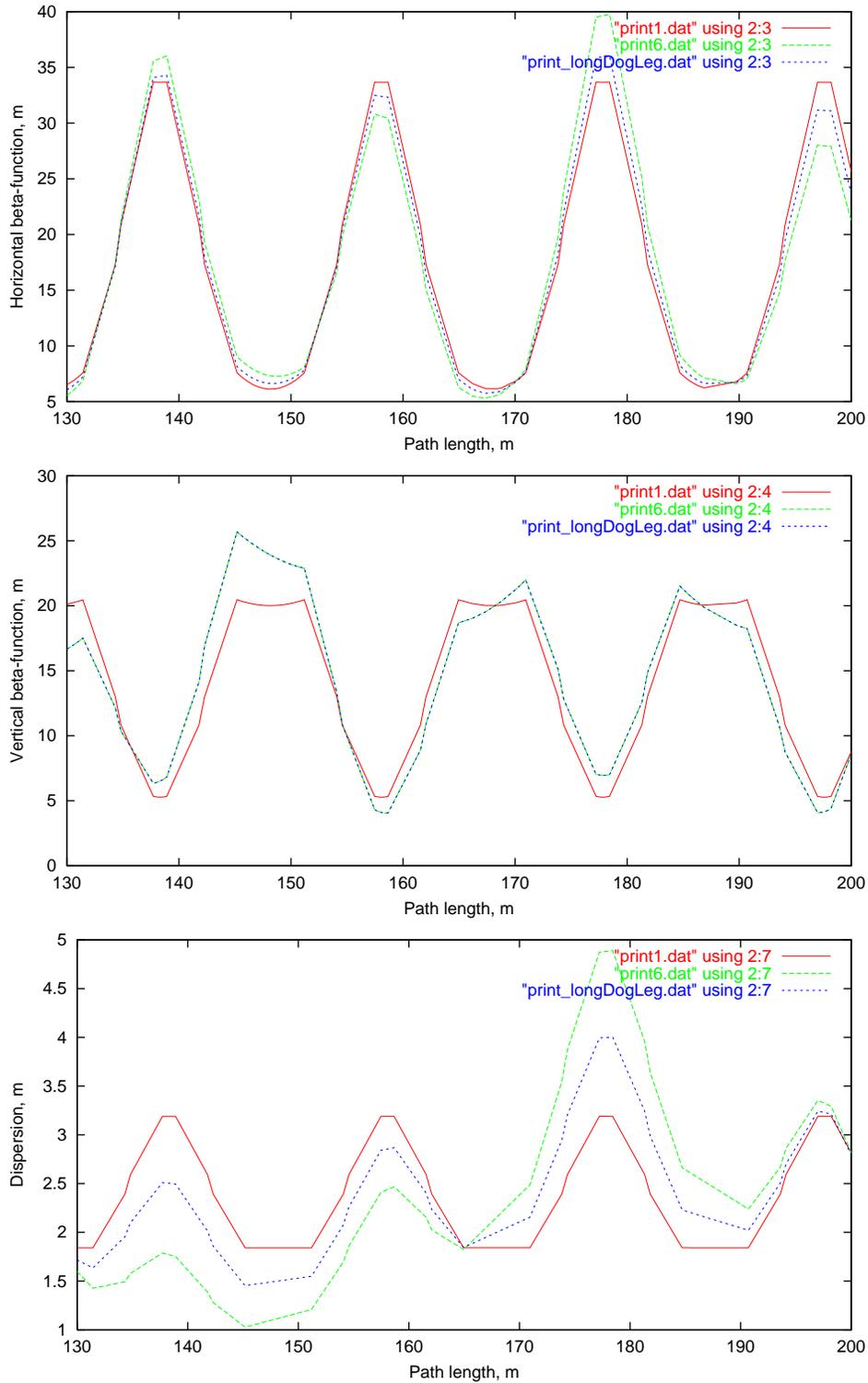


Figure 16: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the injection and extraction bump-magnets. With “short” distance between DogLeg magnets and with distance increased by 0.2 m. Only four periods are shown.

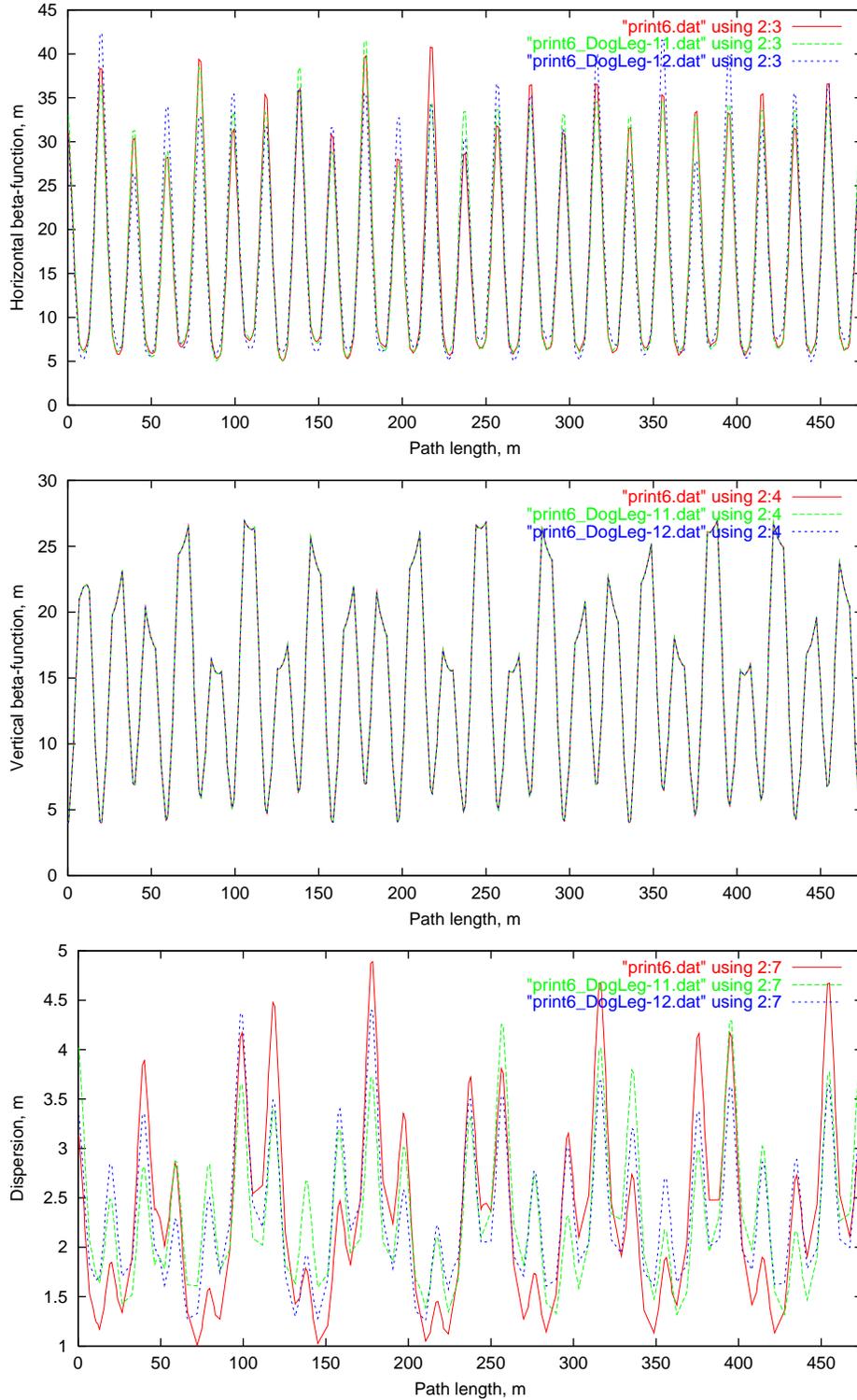


Figure 17: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13”(or long 11 and long 12) straight sections. With multipole harmonics in the injection and extraction bump-magnets.

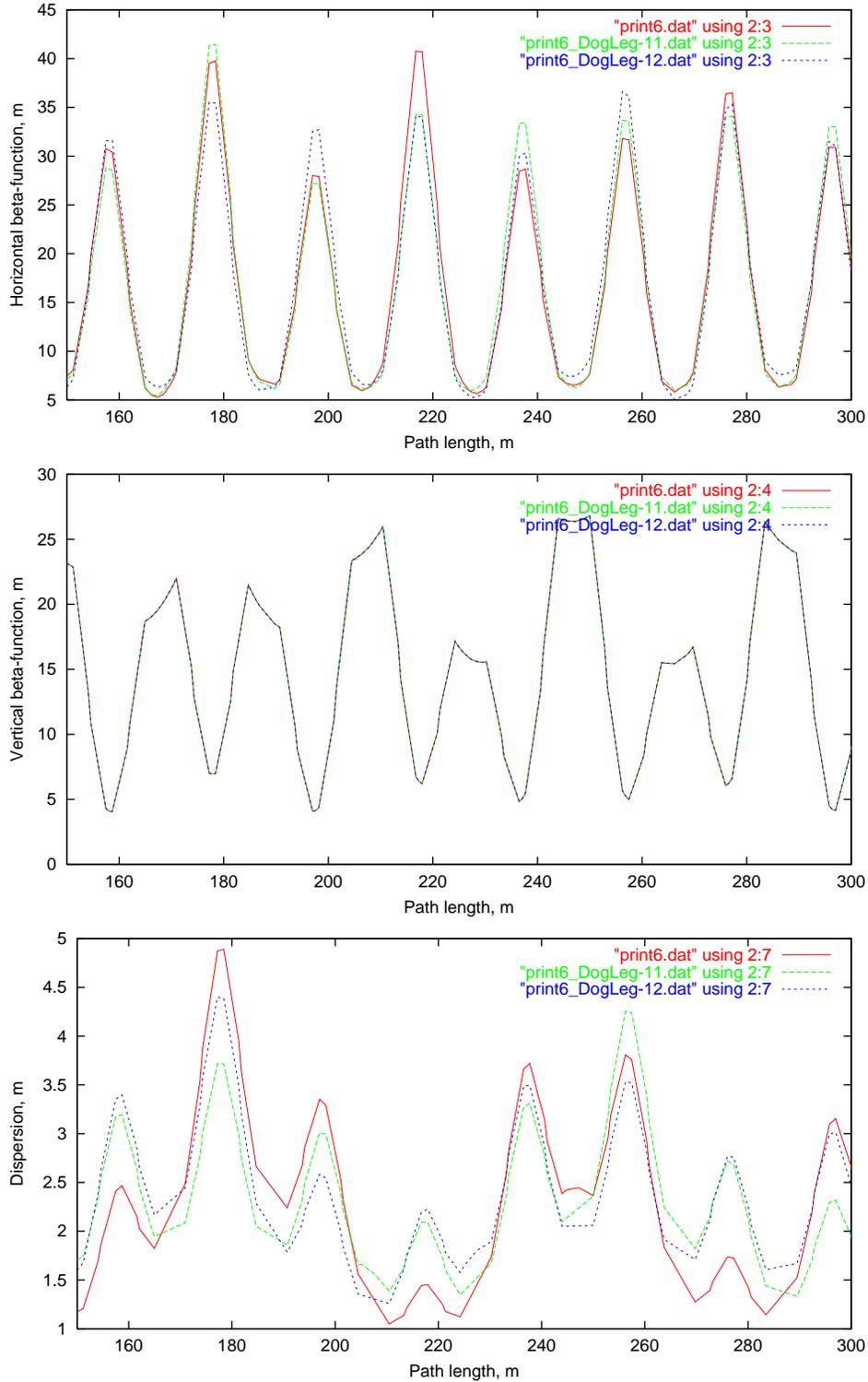


Figure 18: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13”(or long 11 and long 12) straight sections. With multipole harmonics in the injection and extraction bump-magnets. Only seven periods are shown.

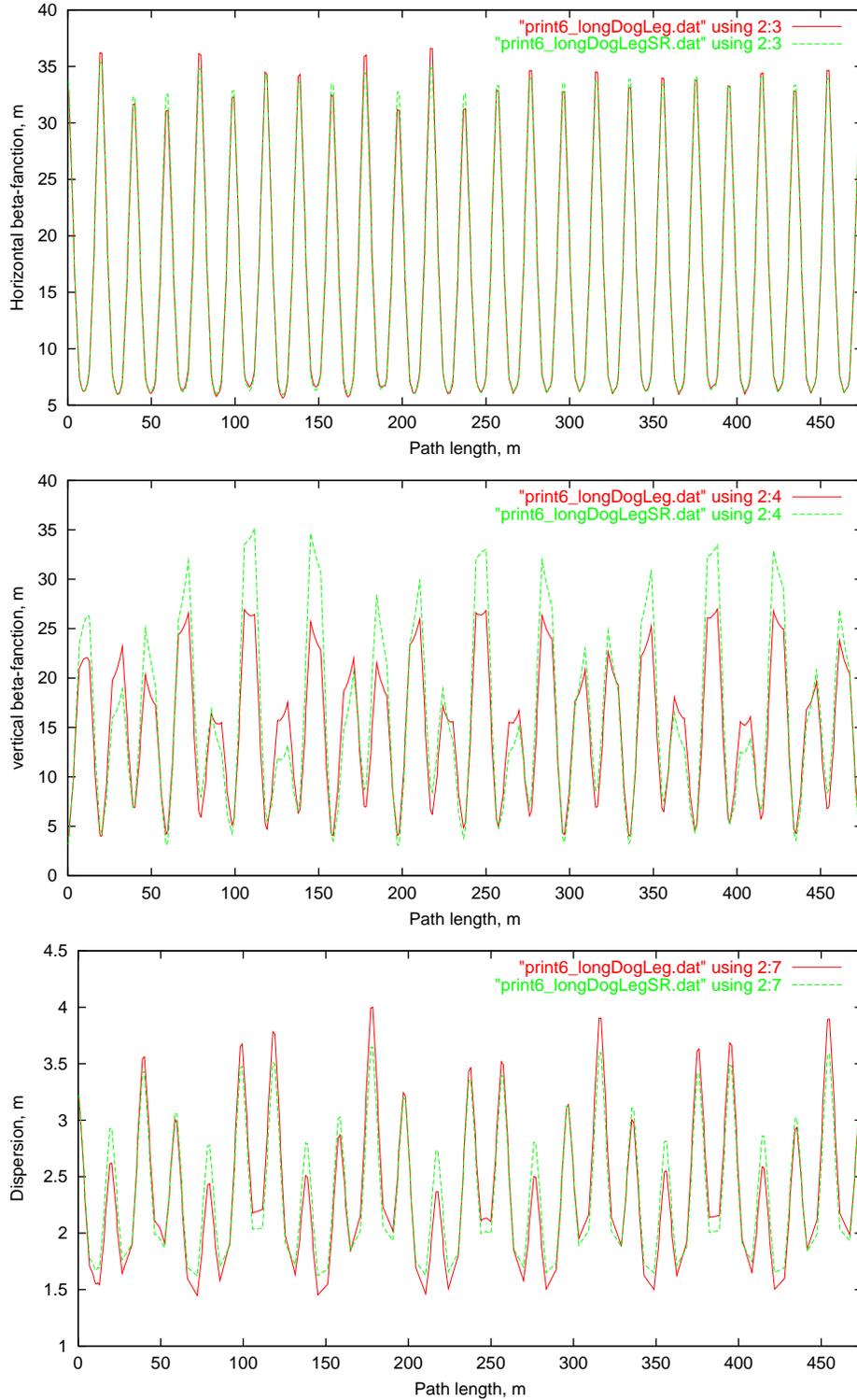


Figure 19: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the injection and extraction bump-magnets. With combination of sector and rectangular magnets in the extraction bump.

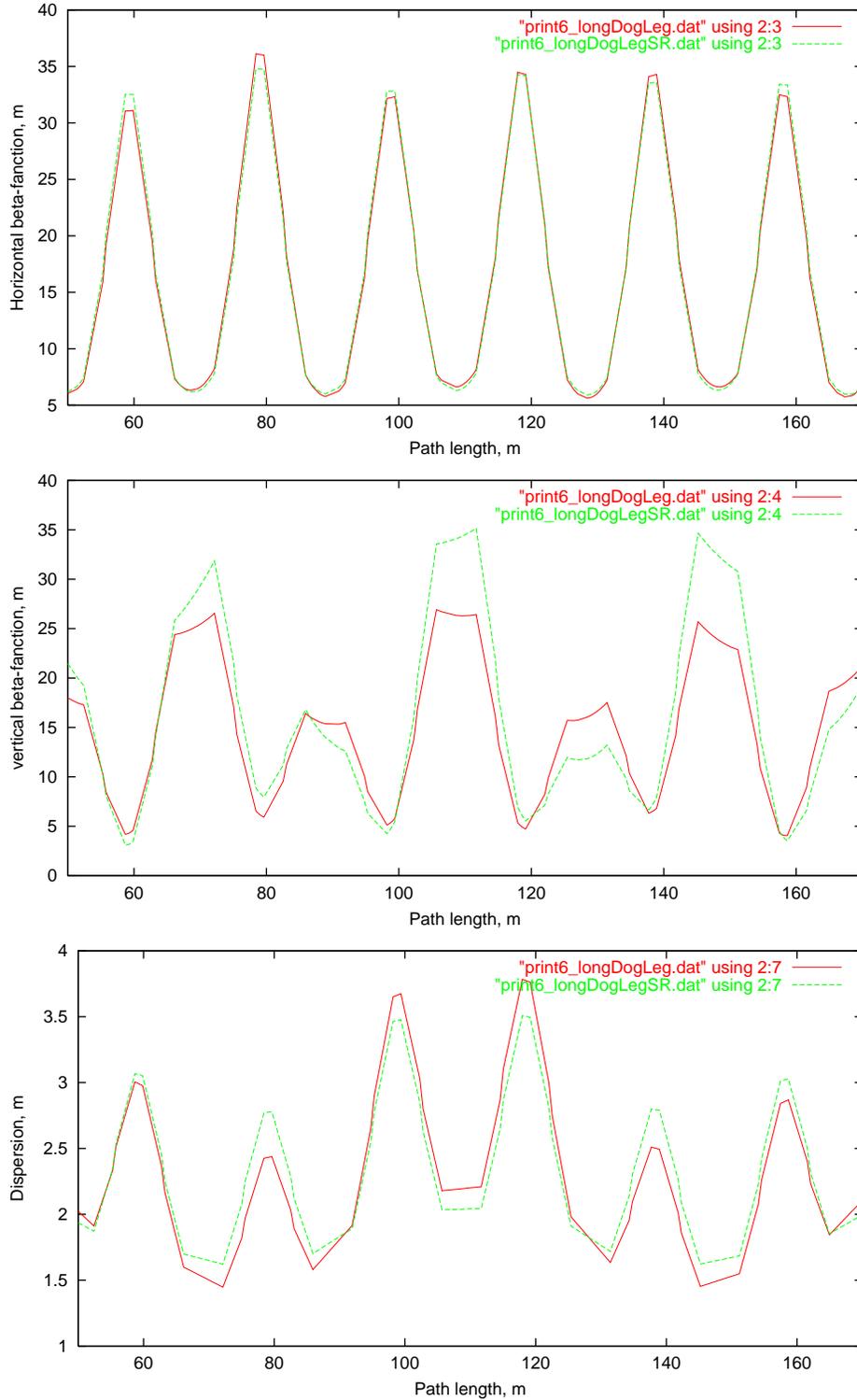


Figure 20: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection with injection bump at “long 01” straight section and with extraction bumps at “long 03” and “long 13” straight sections. With multipole harmonics in the injection and extraction bump-magnets. With combination of sector and rectangular magnets in the extraction bump. Only six periods are shown.

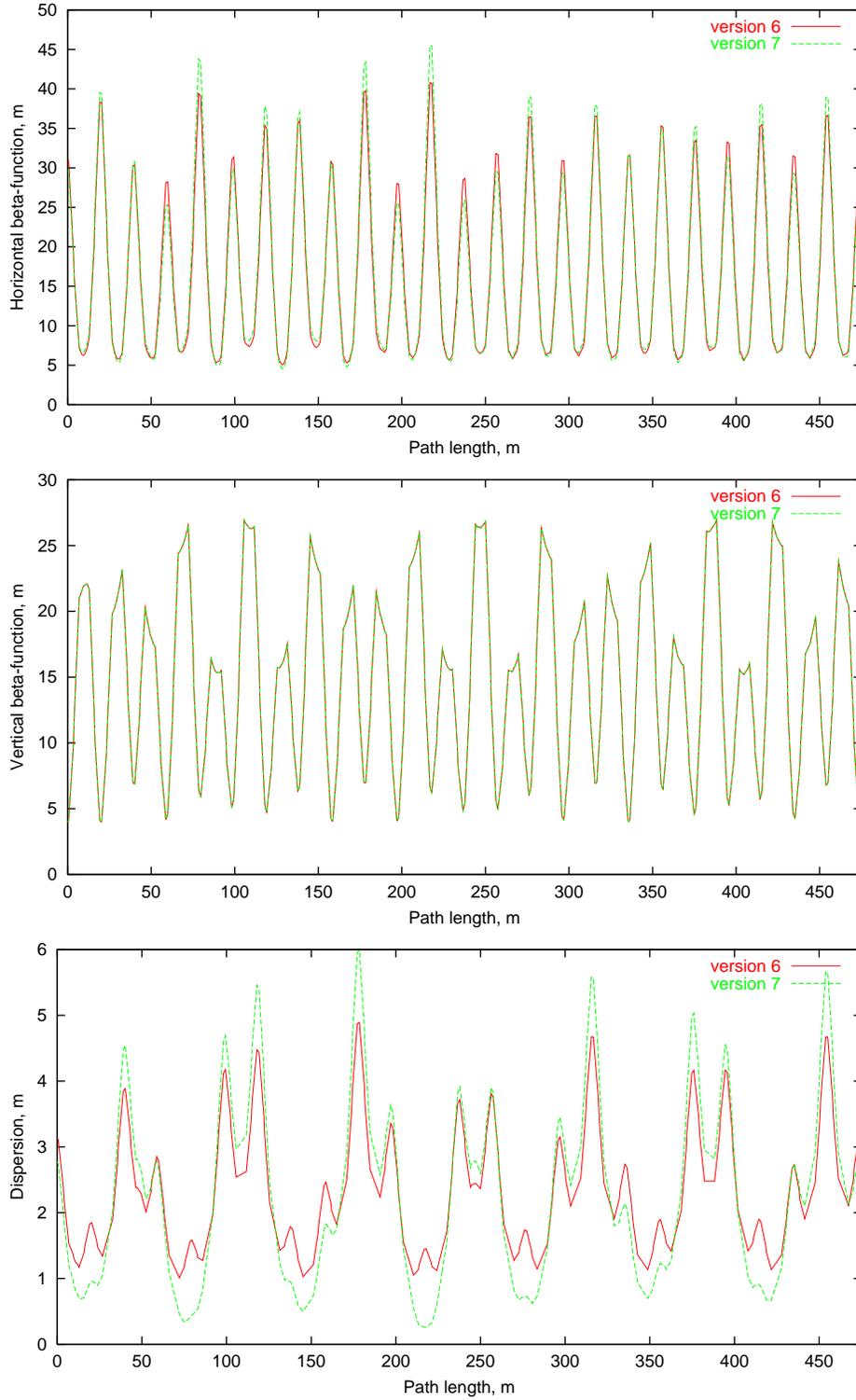


Figure 21: Fermilab Booster horizontal (top), vertical (middle) β functions and horizontal dispersion (bottom) at injection for “version 6” and “version 7”.